PROGRESS REPORT FORM

1. **PI and Co-I Names and Affiliations**:

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2. **Title of Research Grant:**

Simulation of Solar Radiative Transfer in Statistically Inhomogeneous Broken Clouds

3. **Scientific Goal(s) of Research Grant:**

- Constructing a statistically inhomogeneous model of 3D broken clouds;

- Deriving equations for the mean intensity of direct and diffuse radiation and developing methods for their solution;

- Testing the cloud model and its radiative predictions by experimental ARM data;

- Identifying the key factors governing the radiative properties of 3D broken clouds.

4. **Accomplishments in "Bulletized Form"(during last eight months):**

- A statistically inhomogeneous model of 3D broken clouds has been constructed

- Closed equations for the mean intensity of direct and diffuse radiation have been derived and solved.

5. Progress and accomplishments during last eighth months:

We have presented an approach for the stochastic treatment of the solar radiation transfer through three-dimensional (single- and multiplayer) broken cloud fields. The suggested approach is based on a new statistically inhomogeneous model. The term "statistical inhomogeneity" is to be taken in the sense that cloud statistics (the unconditional and the conditional probabilities of the cloud presence) depend on the vertical direction. The constructed statistically inhomogeneous model has been represented as a set of the statistically homogeneous interrelated layers, each homogeneous in the vertical but inhomogeneous in horizontal dimensions.

There are three attractive features of the statistically inhomogeneous model. The model flexibility is the first important feature. The model can describe different combinations of random and maximum cloud overlaps that are normally used in general circulation models. Further, relatively few input parameters of this model can be obtained from observations. This allows one to make a correct comparison of theory against experiment. Finally, the statistically inhomogeneous model is a logical development of the statistically homogeneous models. Thus well-developed methods for statistically homogeneous models can be used as the basis for solving the problem of solar radiative transfer in the statistically inhomogeneous broken clouds. This has been demonstrated by examples of unscattered and diffuse solar radiation. The closed equations for the mean intensity of unscattered and diffuse solar radiation have been obtained and solved (analytical averaging method).

Since the problem of solar radiative transfer in statistically inhomogeneous broken clouds has been successfully reduced to the previously solved one, then the radiative

calculations for the statistically inhomogeneous clouds can be made on the basis of algorithms developed for the statistically homogeneous clouds. Currently, we concentrate our attention to the next stage of the research. The basic aim is to estimate the accuracy of the obtained equations. To do this, we will compare radiative properties of the statistically inhomogeneous broken clouds obtained by (i) the analytical averaging method and (ii) the numerical averaging one. The latter is considered as a reference (exact solutions) and will be made in the following way. Sampling realizations of cloud realizations will be modeled numerically, and the transfer equation will be solved exactly in each of the deterministic realizations; then, the ensemble-average radiative properties of interest to us will be obtained after appropriate processing. This stage will be completed during the next four months.

6. **Electronic figures with paragraph discussions highlighting current research (as appropriate):** NONE

7. **Refereed publications either submitted or published during the current grant FY that acknowledge DOE ARM support:**

Titov, G.A., and E.I. Kassianov, 1999: Radiative effects of inhomogeneous clouds. *Atmos. Oceanic Opt*., **12**, 873-882.

Zuev, V.Å, E.I. Kassianov, and Y.L. Kogan, 2000: Absorption and horizontal radiative transport in 3D broken clouds: Spectral variability, *Atmos. Oceanic Opt*., **13**, 6-12.

Kassianov, E.I., and Y.L. Kogan, 2000: Spectral dependence of horizontal transport and its effect on near-IR absorption, *J. Geophys. Res*. (submitted).

Kassianov, E.I., 2000: Stochastic radiative transfer in multiple broken fields. *Proceedings of the International Radiation Symposium*, St. Petersburg, Russia (submitted).

(Two copies of publications are being sent via mail as requested)

8. Published extended abstracts in current FY that acknowledge DOE ARM

   support:

Kassianov, E.I., 2000: A generalization of stochastic radiative transfer model: Multiple broken layer. *Proceedings of the Tenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, 13-17 March, 2000, San Antonio, Texas, USA.

(Two copies of publication are being sent via mail as requested)

9. Update the status of submitted refereed publications from the previous FY

   progress report: NONE